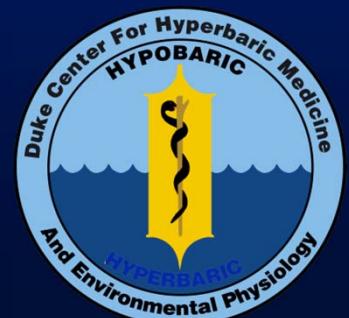
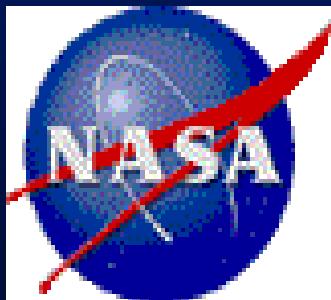


MUSCULOSKELETAL-INDUCED NUCLEATION IN ALTITUDE DECOMPRESSION SICKNESS

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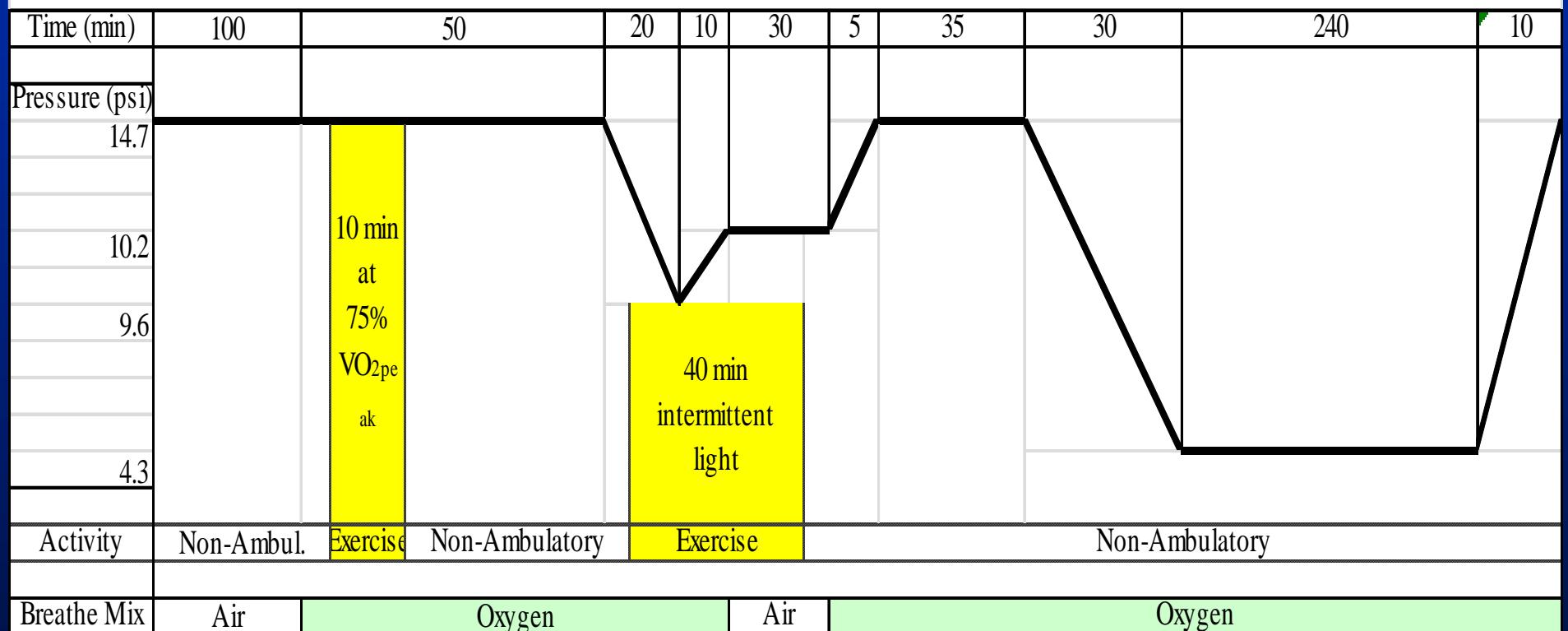
INTRODUCTION

- ◆ Musculoskeletal activity has the potential to both improve and compromise decompression safety
 - enhancing inert gas elimination during oxygen breathing
 - promoting bubble nuclei formation and gas phase separation
- ◆ Timing, pattern and intensity of exercise and the level of tissue supersaturation may be critical to the net effect
 - understanding mechanisms may help quantify risk
- ◆ NASA Prebreathe Reduction Program (PRP) studies
 - combined oxygen prebreathe and exercise followed by low pressure (4.3 psi) microgravity simulation
 - produced two operational protocols used for EVA
 - ❖ CEVIS and ISLE
- ◆ Current study investigates the influence of ambulation exercise on bubble formation and risk of DCS

CEVIS PROTOCOL

(not to scale)

PRP Phase II



METHODS

- ◆ 4 experiments replicate CEVIS protocol, each with exception
 - **Expt 1** – ambulation both preflight and at 4.3 psi
 - **Expt 2** –non-ambulatory preflight; ambulatory at 4.3 psi
 - **Expt 3** –ambulatory preflight; non-ambulatory at 4.3 psi
 - **Expt 4** – reverse heavy/light exercise order; non-ambulatory
- ◆ Decompression stress assessment
 - ultrasound during each of 14 epochs in 4 h 'spacewalk'
 - ❖ aural Doppler for right heart bubbles (Spencer grade 0-IV)
 - ❖ two-dimensional imaging for left heart bubbles (test termin.)
 - venous blood to assess microparticle response to deco stress
- ◆ Fisher Exact Tests (one-tailed) compare test/control groups
- ◆ Plan - 25-50 subjects per experiment
 - trials suspended with 70% confidence of DCS risk >15% or grade IV VGE risk >20%

EXERCISE STRATEGIES



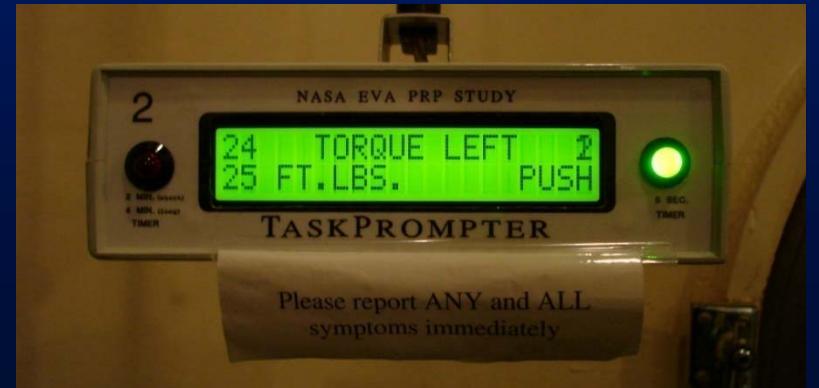
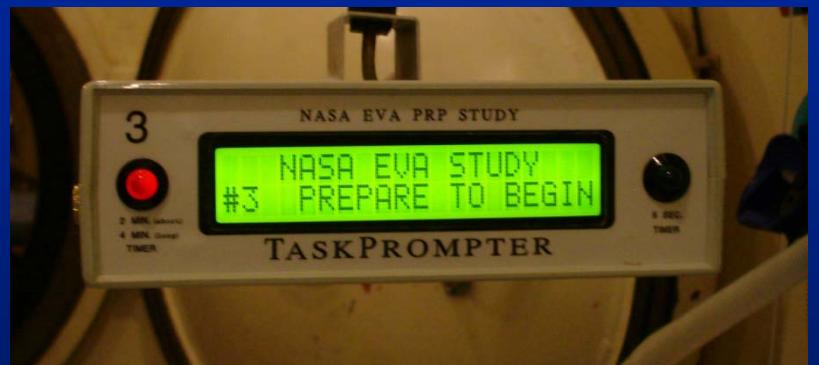
Controlled walking



Suit simulator set up for multiple semi-recumbent intermittent light exercise simulating astronaut tasks

EVA SUIT SIMULATOR EXERCISES

- ◆ 6 exercises
 - sit-ups, arm pulls, full body pulls, torque wrenching, walking
- ◆ Subjects cycle through
 - specific exercises
 - Doppler/2-D echo monitoring
 - Rest break
- ◆ 4 minute intervals for each
 - pace guided by an automated task prompter
 - manual prompting if needed



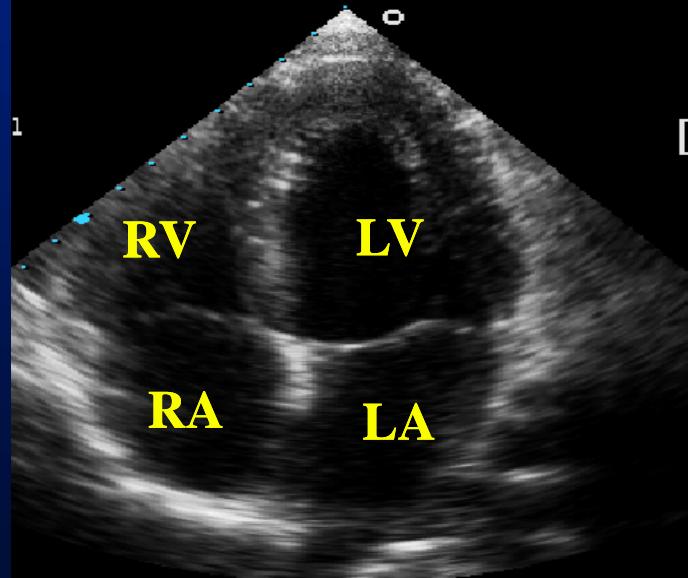
ULTRASONIC ASSESSMENT



Doppler Bubble Detector

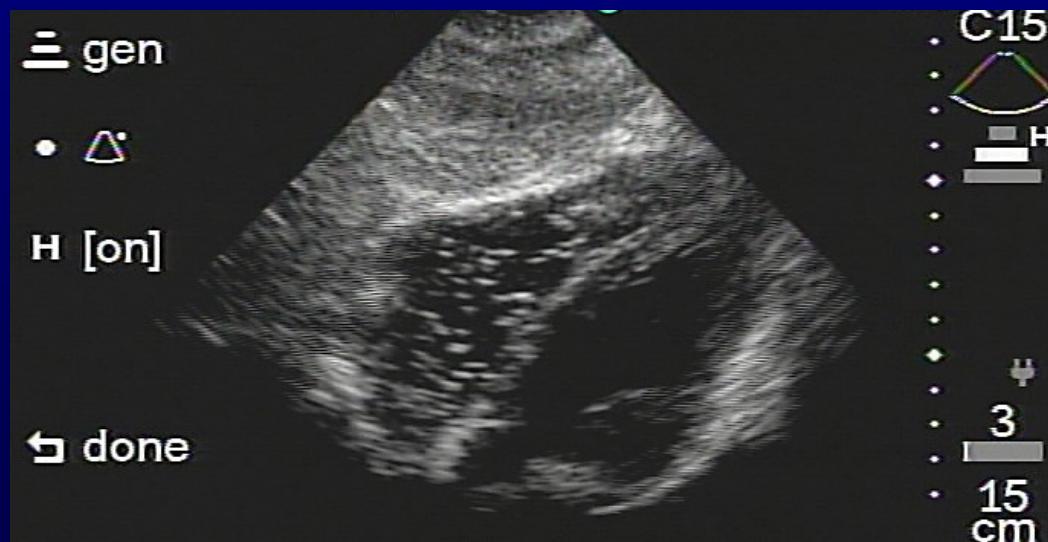


Transthoracic Echo (TTE)



BLOOD MICROPARTICLE ASSESSMENT

- ◆ MPs are 0.1-1.0 μm diameter cell membrane fragments
 - pro-inflammatory
- ◆ 5 mL blood samples drawn at 3 points
 - baseline
 - post-10.2 psi repress
 - post-4.3 psi repress



RESULTS

- ◆ 15 Experiment 1 trials complete
 - 11 male, 4 female
- ◆ **Expt 1 vs. CEVIS**
 - DCS greater
 - ❖ 4/15 (27%) vs. 0/45 (0%), respectively ($p=0.0001$)
 - peak grade IV VGE frequency greater
 - ❖ 4/15 (27%) vs. 3/45 (7%), respectively ($p=0.0334$)
 - cumulative grade IV VGE across all trial epochs not different
 - ❖ 10/183 (5%) vs. 26/630 (4%), respectively ($p=0.220$)
 - microparticle data for 9/15 trials (4 with DCS outcomes)
 - ❖ high variability not yet resolved statistically
- ◆ DSMB review allowed Expt 1 trials to continue
 - to improve statistical power of microparticle assessment

DISCUSSION

- ◆ Expt 1 trial results support thesis that decompression stress is increased by ambulation exercise
- ◆ Additional trials may improve the statistical power to evaluate the relationship between decompression stress and microparticle accumulation
- ◆ Future experiments will test decompression stress of
 - ambulation at altitude (supersaturated) vs. ambulation at ground level (undersaturated)
 - light exercise after heavy exercise induced nucleation

ACKNOWLEDGMENT

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